United States
Department of
Agriculture

Forest Service

**Pacific Southwest
Forest and Range
Experiment Station**

P.O. Box 245
Berkeley
California 94701

Research Note
PSW-356

August 1982

Distribution and Germination of Mamane Seeds

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Scowcroft, Paul G. *Distribution and germination of mamane seeds*. Res. Note PSW-356. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1982. 4 p.

The abundance, distribution, and viability of seeds of mamane (*Sophora chrysophylla*) were determined on study sites within the Mauna Kea Forest Reserve, island of Hawaii. An average of 42 to 305 seeds per m² were found to a depth of 4 cm. About two-thirds of them were on the soil surface or in the litter. More than 75 percent of the buried seeds were found in the first 2 cm of mineral soil. Over two-thirds of the sample quadrats yielded seeds at some sample depth. Twenty-three to 75 percent of the surface seeds and 18 to 68 percent of the buried seeds germinated.

Retrieval Terms: Sophora chrysophylla, germination, seed distribution, Mauna Kea, Hawaii, mamane

The decline of the scrub forest within the Mauna Kea Forest Reserve, island of Hawaii, has been well documented.[1] The relative scarcity of mamane (*Sophora chrysophylla*) regeneration has often been attributed to browsing by sheep (both Mouflon and feral) and feral goats,[2] and studies are continuing to assess the effects of these herbivores.[3] Other possible causes have been suggested, such as water stress induced by competition with dense stands of introduced grasses.

To clarify the problem, a study was made to determine the abundance, distribution, and viability of mamane seeds on and in the upper 4 cm of soil beneath dense grass stands. Four study sites previously established for controlled burning tests were used. Results showed that about one-third of all recovered seeds lay buried in the soil, more than 75 percent of these in the upper 2 cm. The sample variation in number of seeds per quadrat was large. Surface and buried seeds were encountered in more than two-thirds of the sample quadrats. Seed germination as determined in laboratory tests was highly variable, ranging from 18 to 68 percent for buried seeds and from 23 to 75 percent for surface seeds.

STUDY ARE

Study plots
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2560 m elevation. This area was chosen to meet the objectives of the burning tests; it contained extensive grass stands (*fig. 1*), was rarely used by feral sheep, and was easily accessible. Established mamane regeneration was rare. Most established regeneration apparently got its start in the mid-1950's, when sheep control programs greatly reduced browsing, but before the grass cover became dense.

In this open mamane woodland, primarily of old growth trees 5 to 10 m tall, grasses dominate the understory. The common grass species were Kentucky bluegrass (*Poa pratensis*), velvet grass (*Holcus lanatus*), sweet vernal grass (*Anthoxantum odoratum*), heu pueo (*Trisetum glomeratum*), and ripgut brome (*Bromus rigidus*). Bluegrass in particular formed dense stands with mats of litter up to 40 cm deep.

The climate is dry subalpine. The area is located in the rainshadow of Mauna Kea and receives about 53 cm of rainfall annually,[4] most of it during winter months. Daily temperatures av
about 23°C during the
night. Afternoon fog
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Figure 1—Dense stands of grasses, primarily introduced species, dominate the understory vegetation in the Mauna Kea Forest Reserve, island of Hawaii, between about 2100 and 2600 m elevation. Regeneration of mamane in these areas is sparse or lacking.

METHODS

The four sites were at 2380, 2440, 2500, and 2560 m elevation. The upper site was less than 0.8 km from the lowest one. Among the criteria used to select these sites was the presence of mamane seed on and in the soil, as determined by excavation of six randomly located 0.3-m square quadrats to a depth of 4 cm. (Other criteria were that sites be large enough to accommodate a 6.1- by 9.1-m plot with relatively uniform fuel loading, and have enough dry grass to carry a hot fire.)

The soil seed bank at each site was sampled in 1979. Thirty quadrats, each 0.3 m square, were randomly located within a 2-m wide band bordering the established plots. Mamane seeds in the litter and humus were collected from each quadrat. Seeds were also collected separately from the 0- to 2-cm and 2- to 4-cm layer of mineral soil. All seeds were brought into the laboratory, nicked to break seed coat dormancy, and placed in petri dishes on moistened filter paper to germinate. The criteria for germination was radicle emergence. The germination tests ran for 21 days.

ANALYTIC PROCEDURES

The seed bank data consisted of counts for seed abundance (range 0 to 61 per quadrat) and percentages for seed germination (range 0 to 100 percent). The amounts of seed recovered at each site and from each depth were compared using the χ^2-test for two-cell frequency tables.[6] The effects of site and burial depth on seed distribution and germination were examined using two-way and multi-way contingency table analysis.[7] Differences in proportions were tested using procedures for simultaneous comparisons in two-way contingency tables.[8] The 0.05 level of significance was used in all tests.

RESULTS AND DISCUSSION

Seed Abundance and Distribution

Statistical analysis showed that significantly more seeds were recovered at or close to the soil surface (*fig. 2*). An average of 108 seeds/m² were recovered from the soil surface, litter and duff; 43 seeds/m² from the first 2 cm of mineral soil; and 7 seeds/m² from the next 2 cm of soil.

Significantly different amounts of seed were recovered from each of the four sites (*fig. 2*). Site 4 yielded the most (305 seeds/m²) and site 2 the least (42 seeds/m²) with sites 3 and 1 intermediate at 175 and 112 seeds/m², respectively.

The number of seeds recovered at site 2 was probably so small because the site lay beneath a nearly dead mamane tree, its canopy reduced to about 5 percent of its former size. Fine and medium-sized branches were lacking, suggesting that the canopy had been small for about 20 years. An examination of the living canopy and the ground beneath it indicated that seed had not been produced for at least 10 years. Neighboring trees were too far away to add seeds to the site.

Site 4 had the most seeds per unit area, probably because of the high vigor and density of seed-producing trees on and adjacent to the sample plot. Most of the trees were young and showed evidence of having produced much seed in previous years.

I expected site 1, which was dominated by a large, full-crowned mamane, to have more seeds than site 3, which was occupied by a single small mamane tree. The reverse was true. Prolific seed-producing trees grew just uphill of site 3. The combined action of water, wind, and sheep probably moved some of the seed onto the sample area. Seed import was less likely at site 1 because neighboring trees were far removed and because sheep activity ceased about 10 years before it did at site 3, the result of hunting pressure. Without the sheep, the grass at site 1 would have quickly occupied the ground, preventing seed import through overland movement by water and wind. The tree that dominated site 1 was also old. There was no evidence it had produced seeds in the 5 to 10 years before this study.

Seed distribution by depth was not significantly different for sites 1, 2, and 3 (*table 1*), but at site 4, the proportion of surface seeds was significantly greater than at the other sites. Also at site 4, the proportion of seeds in the 2- to 4-cm soil layer was significantly smaller than at site 3. I believe these differences reflect the relative youthfulness of the trees

dominating site 4, and their current large seed-producing capacity.

A large proportion of the quadrats at each site yielded surface seeds (*table 2*). The proportion containing seeds in the upper 2 cm of soil was also large for all sites. Except for site 3, one-third or less of the quadrats yielded seeds from the 2- to 4-cm soil layer.

Seed Viability

Germination was affected by the interaction of site and recovery depth. At sites 1 and 4, differences in percent germination between depths were not significant (*table 3*). Germination for these sites was relatively high, ranging from 43 to 67 percent at site 1 and from 59 to 75 percent at site 4. At site 2, the difference in germination between surface seeds and those recovered from the 2- to 4-cm depth may not have been real—only two seeds were recovered at 2- to 4-cm for testing (*fig. 2*).

Germination was lower at site 2 than at the other sites, perhaps because seed there was older, and hence less viable.

The germination data (*table 3*) may underestimate actual seed viability, a problem inherent in laboratory germination trials. As a working figure to apply to any site occupied by mamane within this ecosystem, I would choose 45 percent as the mean for buried seeds. Previous germination tests of mamane suggest this is a reasonable value.[9]

I believe there were enough buried mamane seeds to reproduce the species in areas supporting dense grass. Assuming that 45 percent of the buried seeds were viable, and about 2 percent of these had lost their seed coat dormancy,[9] my seed density data indicated that between 1 to 7 seeds per 10 m^2 would be ready to germinate if soil moisture was adequate.

Despite this apparent abundance of seed, no seedlings were observed in the study areas during a 3-year period. Near tree-line, above my sampling areas, mamane seedlings were observed during the same period. Here grass cover as well as other understory vegetation was sparse. Water stress induced by competition with dense grass may have prevented the germination or emergence or both of mamane at my four study sites.

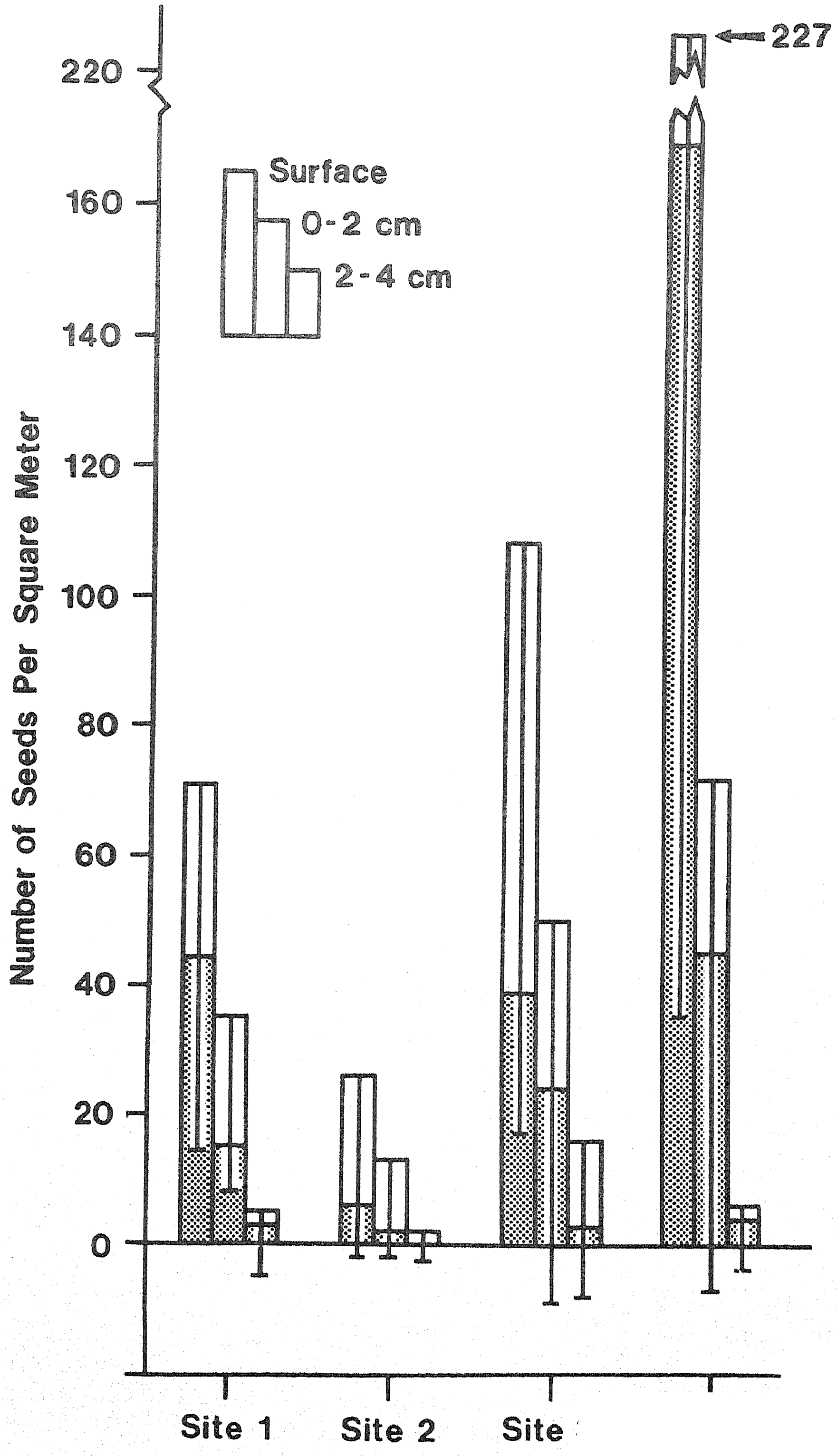

Figure 2—The av
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Alternatively, seedling-destroying insects may be more abundant in areas with dense grass. While determining the abundance of mamane seeds, I observed cutworms (*Agrotis* sp.) at a density of about 140 larvae per m^2.

Acknowledgment:

Research by the Forest Service, U.S. Department of Agriculture, in Hawaii is conducted in cooperation with the Division of Forestry and Wildlife, Hawaii Department of Land and Natural Resources.

NOTES

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[8]Miller, R.G. *Simultaneous statistical inference*. New York: McGraw-Hill Book Co., Inc.; 1966. 272 p.

[9]Scowcroft, Paul G. *Germination of* Sophora chrysophylla *increased by presowing treatment*. Res. Note PSW-327. Berkeley, CA: Pacific Southwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture; 1978. 6 p.

Table 1—*Vertical distribution of seeds at and just beneath the soil surface at four sites on the west flank of Mauna Kea, island of Hawaii*

Recovery depth	Percent distribution			
	Site 1	Site 2	Site 3	Site 4
Surface	63.5a[1]	62.4a	62.2a	74.6b
0-2 cm	31.7a	31.6a	28.8a	23.6a
2-4 cm	4.8ab	6.0ab	9.0a	1.9b

[1]Within each row, values followed by the same letter do not differ significantly ($p \geq 0.05$).

Table 2—*Percent of seed sampling quadrats containing at least one mamane seed, by site and soil depth*

Site	Surface	0-2 cm	2-4 cm	0-4 cm	All depths
1	93	93	30	97	97
2	80	60	23	67	87
3	93	87	47	90	97
4	100	90	33	90	100

Table 3—*Percent germination of mamane seeds recovered from the four sites*

Site	Percent germination		
	Surface	0-2 cm	2-4 cm
1	59a[1]	43a	67a
2	23a	16ab	0b
3	36b	49a	21b
4	75a	63a	59a

[1]Within each row, values followed by the same letter do not differ significantly ($p \geq 0.05$).

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